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On an Adjustable Compensation for an "Invar" Pendulum.

By Richard Inwards.

Since the introduction of the alloy of steel and nickel called "Invar" it has been possible to make pendulums with a very short compensating tube, so that the whole instrument approaches the ideal form of a thin rod supporting a heavy weight.

Some Regulator clocks have been issued with "Invar" pendulums in which the temperature compensation is sought to be effected by the expansion of the bob itself, which is supported at such a place that the metal above the point of suspension expands and contracts to an extent calculated to balance the temperature variations in the length of the pendulum rod. This plan is open to weighty objections from a theoretical point of view, and it becomes a serious matter to alter the compensation if it should not have been correctly made at first.

It is clearly laid down in the late Lord Grimthorpe's book on clocks that the only proper point of support for the pendulum bob is at the centre of oscillation. This, in a 5-inch bob such as shown in the figure, is about $\frac{1}{5}$th of an inch below the centre of gravity of the bob.

The plan I now describe is designed to effect the compensation by a short tube of brass (J in fig. 1), and this is so made that it admits of being shortened or lengthened for exact adjustment by experiment, without taking the clock to pieces, and if over-corrected may be altered as many times as necessary without inserting new pieces of tube, as in the usual way, or altering the position of the bob on the pendulum rod. This is done by means of a timing-nut E which is attached to the brass compensating tube by two screws F F, and when these screws are loosened the nut can be raised or lowered about an inch (without turning the compensating tube) and clamped by the screws in any position finally decided on. The tube J is cut away at the two opposite sides, so as to pass through the curved slots in the timing-nut, as shown black at H in fig. 2. The nut is in the form of a light wheel, and has a hole tapped in the centre, which turns on a screwed part of the pendulum rod, as shown. The screw is of 18 threads to the inch, so that one turn corresponds to a minute a day in time.

On the top of the pendulum bob there is a grip-nut C on the principle of the self-centring drill-chuck, which on being tightened grasps the rod securely and holds the bob when the compensating brass tube is removed for alteration. This nut must, of course, be loosened when the tube has been put in.

The nut G at the bottom is to keep the ends of the slotted tube together, and may itself be used as a timing-nut for fractions of a second per day.

The pendulum rod shown has an expansion of about $\frac{1}{20}$th that of brass.

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On a Periodic Discordance between the Right Ascensions of the Fundamental Catalogues and those of the Greenwich Standard Clock Stars. By W. G. Thackeray.

(*Communicated by the Astronomer Royal.*)

In the introduction to the Greenwich Second Nine-year Catalogue for 1900, p. 28, will be found a comparison between the right ascensions of the fundamental catalogues of Newcomb, Boss, and Auwers and those of the Greenwich standard clock stars. This comparison showed a small but well-marked discordance, varying with right ascension. This discordance Dr. Downing has referred to in the March number of the *Observatory* for 1910, and while he considers it "conceivable that part of the discordance may be due to the effect of magnitude equation," he concludes "it is highly improbable that such a connection would account for the whole or even for the greater part of the discordance in question."

To minimise the effect of magnitude correction, the Greenwich clock stars used in the following comparison have been limited to those between magnitude 3·0 and 4·9. The selection has been made according to the magnitudes given in the clock star list for 1910, which depend on the revised Harvard photometry and the Harvard photometry.

The fundamental catalogues have been compared with these selected Greenwich clock stars for a period extending over fifty years, at the following dates, 1860, 1872, 1880, 1890, 1900, and 1910.

The results for 1860 have been obtained by selecting those days in the years 1853–1867 on which at least six clock stars were observed extending over a period of 12 hours. New clock star lists were formed by carrying back the standard right ascensions of the Greenwich 1872 catalogue, reduced to Newcomb's equinox, with the precessions and proper motions given in Newcomb's fundamental catalogue for 1900; these new clock star places were compared with the clock star list places used in the reductions, and corrections were found to the original clock star places. These corrections were applied to the clock errors used on the selected days, and corrections for the new clock errors were applied to the original reductions. It was not found necessary to alter the adopted daily rates. The stars used for the period 1860 are somewhat fewer than those for the subsequent dates of comparison, and the number of observations for each star on the average is about 15.

For the dates 1872, 1880, 1890, and 1900, the Greenwich star places are the standard right ascensions of clock stars, based on 12-hour groups, printed at the end of the introductions to the successive Greenwich catalogues corresponding to those dates and referred to Newcomb's equinox. The corrections used to refer

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